ELECTRODE STRUCTURE OF A PLASMA DISPLAY PANEL

1. Field of the Invention

The present invention relates to an electrode structure of a plasma display panel (PDP), and more particularly, to an electrode structure of a PDP with a small discharge gap.

2. Description of the prior art

A plasma display panel (PDP) is one kind of flat display using gas discharges to create brilliant images. Advantages of the PDP include thin and lightweight design, large display size, and wide viewing angle. The luminescent principle of the PDP involves the production of ultraviolet (UV) rays by plasma first, followed by irradiation of the UV rays to produce visible light. The production efficiency of plasma greatly influences the luminescent efficiency of the PDP. The luminescent efficiency of the PDP can be improved by many methods. For example, increasing UV production can improve the luminescent efficiency of the PDP, but increasing the luminescent efficiency of the fluorescence material is difficult. Nowadays, change of the filling gas and the electrode structure of the PDP will increase the UV production.

Please refer to Fig.1. Fig.1 is a cross-sectional view of a PDP 10 in the prior art. The PDP 10 includes a front substrate 12 and a back substrate 14 positioned in parallel, a discharge gas (not shown) filled between the front substrate 12 and the back substrate 14, and two sustaining electrodes 16 formed on the surface of the front substrate 12. A discharge gap 17 is defined between the two sustaining electrodes 16. Two auxiliary electrodes 18 are formed above and parallel to the two sustaining electrodes 16 on the front substrate 12. A

plurality of address electrodes 20 are formed on the surface of the back substrate 14 and perpendicular to the sustaining electrodes 16.

The PDP 10 further includes a dielectric layer 22, a protective layer 24, a plurality of ribs (not shown), and a fluorescent layer 26. The dielectric layer 22 covers the front substrate 12, and the protective layer 24 formed above the dielectric layer 22. The ribs are formed parallel to each other on the back substrate 14 for isolating two neighboring address electrodes 20. The fluorescent layer 26 are coated above the address electrode 20 and the sidewalls of each rib for producing red, green or blue light.

Generally speaking, the sustaining electrode 16 is transparent and composed of indium tin oxide (ITO). The transparent electrode is able to penetrate visible light but has a large resistance. The auxiliary electrode 18 is opaque and composed of Cr/Cu/Cr metal layers. The opaque electrode has a poor transparency and good conductivity. Thus, the auxiliary electrode 18 is positioned above the sustaining electrode 16 for increasing the conductivity of the sustaining electrode 16.

Referring to Fig.2, it is a Paschen curve for showing the relationship between the firing voltage (V_f) of the PDP and the multiplication of the filling gas pressure (P value) with the discharge gap width (D value). When the PD value is equal to a constant C, the firing voltage V_f will reduce to a minimum value. In the present PDP process, the pressure P of the filling gas is increased in order to heighten the brightness under a constant firing voltage as shown in Fig.3. The filling gas

is usually a mixture of Xe and Ne gases. However, as shown in Fig.2, an increasing P value leads to an increasing V_f value. In order to maintain the V_f value, the D value (discharge gap) must be decreased. The width of the discharge gap 17, the distance between two sustaining electrodes 16, is determined by the photoresist patterned by a mask. However, the accuracy of the patterned photoresist is limited by the resolution of the optical exposure tool and the characteristics of the photoresist materials. Therefore, the pattern with a smaller distance between two sustaining electrode is not easily and exactly transfer to the dry film photoresist for forming a smaller discharge gap 17. Thereby, the large discharge gap will limit the quality of the PDP 10. In addition, a smaller discharge gap can be formed by the high resolution liquid photoresist, but the material cost will be increased. Moreover, the high standard clean room is needed when using the liquid photoresist, and the fabricating cost of the PDP is also increased.

SUMMARY OF THE INVENTION

An objective of the present invention is to provide an electrode structure of a plasma display panel with a reduced discharge gap.

The present invention provides an electrode structure of a plasma display panel (PDP). The electrode structure is formed on a front substrate of the PDP. The electrode structure includes a first and a second sustaining electrode, and a first gap is defined between the first and the second sustaining electrode. The electrode structure further includes an auxiliary electrode electrically connected to the first

sustaining electrode. The first sustaining electrode has a first side approaching to the second sustaining electrode and a second side far away from the second sustaining electrode.

In addition, the first auxiliary electrode has a first part and a second part, the first part is formed in the first gap, and the second part is formed above the first sustaining electrode and adjacent to the first side of the first sustaining electrode. A second gap exists between the first part of the first auxiliary electrode and the second sustaining electrode, and the width of the second gap is smaller than that of the first gap. The first auxiliary electrode further includes a third part adjacent to the second side of the first sustaining electrode. The third part of the first auxiliary electrode is formed on the surface of the front substrate or on the first sustaining electrode.

The PDP also includes a back substrate parallel to the front substrate, and a plurality of ribs formed on the back substrate and parallel to each other. The ribs are perpendicular to the axial direction of the first auxiliary electrode. The first auxiliary electrode further includes a fourth part parallel to the ribs. The second sustaining electrode includes a third side distal from the first sustaining electrode. The electrode structure also includes a second auxiliary electrode adjacent to the third side of the second sustaining electrode.

A first lithographic process patterns the first and the second sustaining electrodes, and a second lithographic process patterns the first auxiliary electrode. In the present invention, the misalignment of the auxiliary electrode and the sustaining electrode is obtained from twice lithographic processes for forming a smaller discharge gap. As a result,

the discharge gap will not be limited by the resolution of the optical exposure tools and photoresist materials in the present invention. Therefore, the discharge gap is reduced and the image quality of the PDP can be improved.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment, which is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a cross-sectional view of a PDP in the prior art.

Fig.2 is a Paschen curve for showing the relation between the firing voltage (V_f) and the product of the filling-gas pressure (P) and the discharge gap (D).

Fig.3 is the relationship graph between the brightness, firing voltage (V_f), and filling-gas pressure of the PDP.

Fig.4A to Fig.4G are cross-sectional views of the electrode structures in the first embodiment according to the present invention.

Fig.5A and Fig.5B are cross-sectional views of the electrode structure in the second embodiment according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Please refer to Fig.4A to Fig.4G which are the cross-sectional views of the electrode structures of a PDP 30 in the present invention. As shown in Fig.4A, the electrode structure is formed on a front substrate 32 of the PDP 30. The electrode structure includes a first sustaining electrode

34, a second sustaining electrode 36, a first auxiliary electrode 44, and a second auxiliary electrode 42. The first 34 and second 36 sustaining electrodes are formed on the surface of the front substrate 32 and a first gap 38 is defined between these electrodes. In addition, the first auxiliary electrode 44 has a first part 44a formed on the surface of the front substrate 32 in the discharge gap 38, a second part 44b formed above the first sustaining electrode 34, and a third part 44c for connecting the first part 44a and the second part 44b. The second auxiliary electrode 42 is formed above the second sustaining electrode 36. A second gap 48 is defined between the first part 44a of the first auxiliary electrode 44 and the second sustaining electrode 36 and the second gap 48 is a discharge gap. As shown in the top view, the first 34 and the second 36 sustaining electrodes are parallel to the first 44 and the second 42 auxiliary electrodes.

Besides, the PDP 30 also includes a back substrate (not shown) parallel to the front substrate 32. A plurality of ribs 50 are formed on the back substrate, parallel to and spaced apart from each other with equal distance. A third part 44c of the first auxiliary electrode 44 is perpendicular to the first 34 and the second 36 sustaining electrodes, and parallel to the ribs 50. Further, the third part 44c of the first auxiliary electrode 44 is in opposition to the ribs 50 on the back substrate to avoid the reduction of the transparency of the PDP 30.

The first 34 and second 36 sustaining electrodes are transparent electrodes and formed of indium tin oxide (ITO). The resistance of ITO is very large and easily affects the discharge efficiency. Therefore, an auxiliary electrode

composed of Cr/Cu/Cr alloy is used to reduce the resistance. Moreover, a smaller discharge gap 48 is formed by the sustaining electrode 36 and the first part 44a of the auxiliary electrode 44 in the first gap 38 so the the problem in the prior art can be solved by reducing the firing voltage to increase the quality of the PDP 30.

As shown in Fig.4B, the difference between Fig.4B and Fig.4A is the position of the second part 44b of the first auxiliary electrode 44. In Fig. 4B, the second part 44b is located on the surface of front substrate 32 rather than on the sustaining electrode 34 in Fig. 4A. As well, the second part 44b of the first auxiliary electrode 44 can be located on both surfaces of the first sustaining electrode 34 and the front substrate 32.

As shown in Fig.4C, the first part 44a of the first auxiliary electrode 44 can be formed in the first gap 38 and adjacent to the first sustaining electrode 34. As a result, the distance between the first auxiliary electrode 44 and the second sustaining electrode 36 is shortened to a second gap 48. The second gap 48 is smaller than the first gap 38 for achieving the objective of reducing the firing voltage in the present invention.

As shown in Fig.4D, the front substrate 32 of the PDP 30 includes an electrode structure having a first sustaining electrode 34, a second sustaining electrode 36, and a first auxiliary electrode 40. The first 34 and second 36 sustaining electrodes are formed on the surface of the front substrate 32, and a first gap 38 is defined therebetween. The first auxiliary electrode 40 is electrically connected to the first

sustaining electrode 34. The first sustaining electrode 34 includes a first side 341 and a second side 342, the first side 341 is near the second sustaining electrode 36, and the second side 342 is far away from the second sustaining electrode 36. Besides, the first auxiliary electrode 40 includes a first part 40a, a second part 40b, and a third part 40c. The first part 40a is formed on the surface of the front substrate 32 in the first gap 38, the second part 40b is formed on the first sustaining electrode 34 adjacent to the first side 341, and the third part 40c is positioned near the second side 342 of the first sustaining electrode 34. The first auxiliary electrode 40 and the second sustaining electrode 36 are separated by a second gap 48. The width of the second gap 48 is smaller than that of the first gap 38 for achieving the purpose of voltage reduction in the present invention. The third part 40c of the first auxiliary electrode 40 is formed above the first sustaining electrode 34 and approaching to the second side 342 of the first sustaining electrode 34. The third part 40c of the first auxiliary electrode 40 can also be positioned on the surface of the front substrate 32 (not shown), or above the first sustaining electrode 34 and the front substrate 32 at the same time. The first auxiliary electrode 40 also includes a fourth part 40d positioned between the second part 40b and the third part 40c. The position of the fourth part 40d is opposite to the ribs 50 on the back substrate (not shown), so the transparency of the PDP 30 will not be reduced by the fourth part of the auxiliary electrode 40d. In addition, each part of the first auxiliary electrode 40 can be electrically connected. A second auxiliary electrode 42 is also formed above the second sustaining electrode 36 to reduce the resistance of the second sustaining electrode 36.

As shown in Fig.4E, the first auxiliary electrode 40 includes only the first part 40a and the second part 40b. The first part is formed in the first gap 38, and the second part 40b is located above the first sustaining electrode 34 and adjacent to the first side 341 of the first sustaining electrode 34. Both the third 40c and fourth part 40d are omitted in this embodiment to increase the transparency of the entire front substrate 32.

As shown in Fig.4F, a first 44 and a third 45 auxiliary electrodes are positioned between the first 34 and the second 36 sustaining electrodes. The first auxiliary electrode 44 electrically connects to the first sustaining electrode 34 via a connecting electrode 52a and the third auxiliary electrode 45 electrically connects to the second sustaining electrode 36 via a connecting electrode 52b. A first gap 38 is defined between the first 34 and the second 36 sustaining electrodes. The first 44 and the third 45 auxiliary electrodes are both located on the first gap 38. A second gap 48 is defined between the first auxiliary electrode 44 and the second sustaining electrode 36, and a third gap 46 is defined between the third auxiliary electrode 45 and the first sustaining electrode 43. The widths of the third gap 46 and the second gap 48 are both smaller than that of the first gap 38 formed by the first 34 and the second 36 sustaining electrode. Therefore, the purpose of reducing the firing voltage of the PDP 30 is again achieved.

As shown in Fig.4G, two L-sharp first 34 and second 36 sustaining electrodes are formed in opposition to each other on the surface of the front substrate 32. A first gap 38 is

further defined between the first 34 and the second 36 sustaining electrodes. A first auxiliary electrode 44 is formed on the surface of the front substrate 32 in the first discharge gap 38 and the first auxiliary electrode 44 is formed adjacent to the first sustaining electrode 34. In addition, a second auxiliary electrode 42 is formed on the surface of the second sustaining electrode 36. The second sustaining electrode 36 has different distances to the first auxiliary electrode 44 for forming a second gap 48 and a third gap 58, respectively. The first auxiliary electrode 44 is electrically connected to the first sustaining electrode 34 and the second auxiliary electrode 42 is electrically connected to the second sustaining electrode 36. The second gap 48 and the third gap 58 are both smaller than the first gap 38. Therefore, the smaller discharge gaps 48, 58 can be used to reduce the firing voltage of the PDP 30. In addition, the first auxiliary electrode 44 can be sinmultanelusly arranged on the surface of the front substrate 32 as well as on the first sustaining electrode 34.

In this embodiment, two lithographic processes are used to form these sustaining electrodes 34, 36 and these auxiliary electrodes 40,44, 42, respectively. Therefore, a smaller discharge gap 58 is obtained by properly arranging the relative position of these auxiliary electrodes 40, 42, 44 and these sustaining electrodes 34, 36.

Please refer to Fig.5A and Fig.5B. Fig.5A and Fig.5B are the cross-sectional views of another embodiment of a PDP 60 according to the present invention. As shown in Fig.5A, the PDP 60 has a front substrate 62 and an electrode structure including a sustaining electrode 64, a first auxiliary

electrode 66, a second auxiliary electrode 68, and a third auxiliary electrode 70. The sustaining electrode 64 is formed on the surface of the front substrate 62. The first auxiliary electrode 66 is also formed on the surface of the front substrate 62 and parallel to the sustaining electrode 64. A first gap exists between the sustaining electrode 64 and a first auxiliary electrode 66. A second auxiliary electrode 68 is also positioned on the surface of the front substrate 62 and parallel to the sustaining electrode 64. A second gap 72 exists between the sustaining electrode 64 and the second auxiliary electrode 68. The second gap 72 is smaller than the first gap 78, therefore, the firing voltage of the PDP 60 can be reduced.

The sustaining electrode 64 has a first side 641 near the second auxiliary electrode 68 and a second side 642 far from the second auxiliary electrode 68. The third auxiliary electrode 70 is located near the second side 642 of the sustaining electrode 64.

There is no sustaining electrode formed beneath the first 66 and the second 68 auxiliary electrodes. As shown in Fig.5A, two connecting electrode 76 are formed between the first 66 and the second 68 auxiliary electrodes for electrically connecting the two auxiliary electrodes 66,68. Besides, the PDP 60 includes a back substrate (not shown) positioned parallel to the front substrate 62, and a plurality of ribs 74 formed on the back substrate 62. The connecting electrodes 76 are positioned in opposite and parallel to the ribs 74 for avoiding the reduction of the transparency of the PDP 60.

Further, the connecting electrode 76 can be omitted for

simplifying the fabricating process and increasing the transparency of the PDP 60. The first auxiliary electrode 66 and the second auxiliary electrode 68 will not be connected in the same pixel area, but rather, can be connected in the pad area (not shown) at the edge of the PDP 60.

As shown in Fig.5B, in order to increase the discharge efficiency of the PDP 60, a fourth auxiliary electrode 67 is further formed on the surface of the front substrate 32. The fourth auxiliary electrode 67 is positioned between the first 66 and the second 68 auxiliary electrodes. A first gap 78 exists between the first auxiliary electrode 66 and the sustaining electrode 64, a second gap 72 exists between the second auxiliary electrode 68 and the sustaining electrode 64, and the third gap 79 exists between the fourth auxiliary electrode 67 and the sustaining electrode 64. The second gap 72 and the third gap 79 are smaller than the first gap 78. The second gap 72, which is the smallest gap, is the discharge gap of the PDP 60.

In this embodiment, a sustaining electrode 64 and plurality of auxiliary electrodes 66, 67, 68, 70 are used for obtaining a smaller discharge gap 72 between the auxiliary electrode 68 and sustaining electrode 64.

Compared with the prior art, the present invention uses the misalignment of two electrodes to obtain a smaller discharge gap. A first lithographic process is first used to form the sustaining electrodes and a second lithographic process is further used to form the auxiliary electrodes on the surface of the sustaining electrodes and near the sustaining electrodes. Therefore, the discharge gap formed

by the auxiliary electrode and the nearby sustaining electrode is not limited by the resolution of the traditional exposure tools or the characteristics of the photoresist materials. A smaller discharge gap can be obtained to improve the image quality of the PDP.

Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.